CHAPTER 2
THEORY, CONTEXT AND METHODS

In this chapter I begin with a brief discussion of the theoretical perspective which undergirds this work. The second section consists of a description of the instructional context in which the data for this study were collected, followed by more detailed information about the data, and methods of analyzing those data used for this dissertation.

THEORETICAL PERSPECTIVE

All aspects of this research are informed by a sociocultural perspective, meaning that this work is premised on the idea that cognition itself is a fundamentally and inextricably socially-embedded phenomenon. Learning and development occur within rich social contexts and these contexts both contribute to and are simultaneously shaped by interactions among participants and with the “tools” of the activity in which they are engaged (e.g. specific language, certain ways of evaluating evidence and warrants, and material artifacts) (Rogoff, Wertsch, Lave & Wenger, ). With this lens, it is helpful to think in cultural terms about learning environments such as classrooms. The classroom is viewed as a “community of learners” who share (or are being enculturated to share) expectations about the purposes and ways of behaving in school. One of these “norms,” is that school is, in large part, a place to learn to think within multiple traditions [Phillips, 1993 #194; Adler, 1982 #193]. The study of history, for example, may require a
particular set of “tools” that may be different in some ways from the “tools” for the study of science, or art, or mathematics. Student learning of these fields is measured by the changes in the ways children participate in the practice of doing science, history, art or mathematics (Rogoff, 1998; Rogoff, Matusov, & White, 1996; van der Veer & Valsiner, 1994; Wertsch, 1991). With a sociocultural perspective, at higher levels of mental function, *instruction* is critical to learning and may take many forms. Most obvious is instruction by more experienced and knowledgeable people in a society (often teachers), but also critical are peers [Forman, 1985 #192] and, indeed, cultural artifacts (Lave & Wenger, 1991).

In addition, with this perspective, which is built upon Vygotskian foundations, the notion of “tools” has particular importance. Concepts, strategies for approaching problems, words, and graphical symbols are all considered “tools” people use to advance to higher levels of mental functioning. As Davydov and Radzikhovkii have described Vygotsky’s position, “all the ‘tools’ that are developed artificially by humanity are the elements of culture. This was not a simple assertion, but a concrete proposal for the scientific analysis of the sociohistorical determination of mind” (1985, p. 54). Thus, within a classroom context, analysis that identifies the range of “tools” (writ large) at play is important for understanding the kinds of learnings that may have been possible for participants in that context.

For this dissertation study, I use an interpretive case study methodology (Merriam, 2001) of one classroom engaged in a unit of study on *Motion Down Inclined Planes*. Case study, with its focus on process, is a particularly good match with the sociocultural perspective that I bring to this research to the extent that the unit of analysis for this work
is individuals in interaction with one another and in interaction with cultural tools (broadly writ to include ideas, materials, texts generated by the children and texts generated by the researchers) (Rogoff, 1982; Wertsch, 1991). This is an interpretive case study to the extent that I am interested in more than simple rich description (although this would be valuable in its own right), and also wish to analyze the discourse and activity for what they reveal about students’ engagement in scientific reasoning and the development of their thinking about objects in motion. More in-depth discussion of my methodology will follow the next section which provides a general description of the instructional context in which data for this study were collected.

THE INSTRUCTIONAL CONTEXT

Guided Inquiry supporting Multiple Literacies

The classroom teacher featured in this research was a member of a professional development Community of Practice (Palincsar, Magnusson, Marano, Ford, & Brown, 1998). This community met regularly for three years to co-construct effective teaching practices consistent with a particular teaching orientation called Guided Inquiry supporting Multiple Literacies (GiSML; Magnusson & Palincsar, 1995). From this orientation, instruction unfolds according to cycles of investigation set within a particular problem space; that is, in the pursuit of a guiding question that is broad and identifies a general conceptual terrain (e.g., What influences the motion of objects?). The recursiveness of multiple cycles of investigation promotes meaningful learning - particularly with respect to scientific inquiry. For example, one needs sufficient experiences examining natural relationships among phenomena (e.g., the relationship
between mass and speed of a moving object, given a set amount of force, or the relationship between speed and momentum, given a set amount of mass) before one can meaningfully test explanations for these phenomena.

Inquiry within an investigation is guided by specific questions (e.g., How does mass affect the speed of a ball rolling down an inclined plane?) or a particular phenomenon (e.g., a ball rolling down an inclined plane and striking a can), and proceeds through phases of different aspects of investigation: preparing to investigate, investigation (data collection and analysis), preparing to report, and reporting. Integral to this orientation is the conception of the classroom as a community of inquiry (The Cognition and Technology Group at Vanderbilt, 1994; Wells, 1995). Hence, the investigations and documentation of data gathered in the course of the investigation are conducted in pairs or small groups. Furthermore, a critical feature of the instruction is the reporting phase during which the investigative teams share their data with the whole class, contributing new claims and evidence for the class’s consideration, as well as speaking to evidence they have to support or refute extant claims. This is followed by whole class discussion regarding claims about which there is consensus, claims that have been sufficiently refuted by evidence from the investigative groups, and claims that need further investigation.

In the course of GIsML instruction, students and teachers participate in two forms of investigation. In first-hand investigations, children directly explore the physical world, manipulating variables in phenomenon – they are investigating, making observations and measurements, and drawing conclusions about how the world works. In second-hand
*investigations* children inquire about others’ investigations and interpretations of phenomena, typically from consulting text-based information.

The ultimate goal of GIsML instruction is to not only support children’s learning of scientific understandings, but to enable students to experience, understand, and appreciate the ways in which these understandings have evolved by using the tools, language, and ways of reasoning that are characteristic of scientific inquiry (White & Frederiksen, 1998; Driver, et al., 1994; Lemke, 1990).

**The Unit of Study: Motion Down Inclined Planes**

**Overview & Curricular Goals**

The participants in this study spent more than 11 instructional hours, over 10 days, investigating questions such as: whether the mass of a ball affects its speed going down a ramp, whether changing the height of the ramp affects speed, whether faster balls will hit cans farther than slower balls and whether heavier balls will hit cans farther than lighter balls. Figure 1 captures the substantive and scientific reasoning goals for this unit of study. The design of this unit of study drew upon activities the *Balls and Ramps* unit of the *Insights* Curriculum (Educational Development Center, 1997).

--------INSERT FIGURE 1 ABOUT HERE--------

A table showing the days of instruction with information about what transpired each day is provided in Appendix A. This table shows the type of investigation the class engaged in (first-hand and/or second-hand) as well as the main topics of discussion each day.
Materials for First-hand Investigations

To investigate the motion of balls down inclined planes in a first-hand fashion, the children used wooden ramps and blocks and metal ball bearings and cans, a timer, and paper for recording data. The surface of the ramps had a groove cut into it to allow the ball to roll down a straight path. The class used a 6-foot long wooden ramp during a teacher-led first-hand investigation and 4-foot long wooden ramps when working in pairs during another first-hand investigation.

The Notebook Texts

There were two notebook texts designed for this unit of study. First, I describe the notebook texts in general, and then the two specifically used in the Motion unit of study. The innovative texts that the principal investigators and others involved in the GIsML research project have been designing and investigating are a hybrid of: exposition, narration, description, and argumentation. In many respects, notebook texts represent a think-aloud on the part of a fictitious scientist, Lesley, who documents: the purpose of her investigation, the question(s) guiding her inquiry, the investigation procedures in which she is engaged, the ways in which she is gathering and choosing to represent her data, the claims emerging from her work, the relationships among these claims and her evidence, the conclusions she is deriving and the new questions that are emerging from her inquiry.

There are a number of features that are present in these texts that are consistent with promoting scientific literacy. For example, diagrams are used to illustrate the set-up of the investigation materials. Figures are used to depict data that students can interpret, along with the scientist. Tables model the various ways in which data can be arrayed, and the narrative accompanying the table models the activity of interpreting these data.
There are opportunities for the scientist to revise her thinking based on the collection of additional or more precise data. Students are supported in tracing the source and nature of these revisions. There are also reference materials included in these texts that serve to advance the inquiry. For example, in a notebook entry regarding light (written for upper-elementary students), the scientist includes what she has learned from studying Newton’s investigations of light and color. This provides the opportunity for the scientist to model the use of a second-hand investigation as she critically reads and interprets reference information about Newton’s work, and indicates how she will formulate claims from this information to advance her own inquiry. This type of reference information is also useful to enriching the conceptual information with which children can work.

Yet another feature of these notebooks is the extent to which they portray the ways in which scientists interact with one another and observe particular conventions to facilitate these interactions. For example, in the notebook text described above, Lesley notes that fellow scientists were not persuaded by her data because they were inexact, leading her to use an instrument that will provide more exact data and a process that can be more readily replicated.

At the primary level (students in Grades K-2), the GIsML notebook texts take the form of “Big Books” that begin with several illustrated pages depicting a scene that Lesley observed. These pages provide a concrete representation of what prompted her questions and subsequent investigations. This allows the students to follow Lesley’s train of thought from a real-life situation (depicted in the illustrations) to a question and formulation of a model to represent the situation, as well as the procedures she uses to test a particular aspect of the real-life situation.
Figure 2 below illustrates the first pages of the first notebook text the children encountered in this unit of study. Since this unit of study begins with a second-hand investigation, the notebook text is used to introduce the children to the phenomenon of objects traveling down inclined planes (in this case, sleds traveling down a snowy hill). In Notebook 1, Lesley is puzzled when two sledders, who are clearly of different sizes, get to the bottom of the hill at the same time. She proceeds to model the phenomenon using a ramp and balls of different sizes. She depicts her thinking about constructing fair trials, records and organizes her data, and generates hypotheses from those data. In Notebook 2, which follows students’ first-hand investigation of momentum, Lesley strategizes and investigates how to help circus clowns, who are – as only circus clowns might – trying to get a birthday cake to an elephant some distance away, by rolling down a ramp in an over-sized go-cart and crashing into a box with the cake on top, sending the cake (on the box) toward the elephant. Sadly, the box and the cake do not quite reach the elephant. Lesley speculates that one solution might be to change the mass of the go-cart, thereby giving it more force to push the box to the elephant. Once again, she models the problem, runs trials, gathers and represents her data, and considers the relationship between this problem and the real-world phenomenon that she is trying to address.

The notebook texts are designed with the assumption that they will be read and discussed in a highly interactive manner. The children are encouraged to critique Lesley’s thinking; they conduct mini-thought experiments in the course of reading the notebook text (e.g. given a mass that is in-between the mass sizes with which Lesley has investigated, the children interpolate the data they would predict from that mass); they
make their own set of claims from Lesley’s data before learning about Lesley’s claims; and they evaluate whether or not Lesley’s claim can be supported by her data.

Participants

This research took place at Fieldview Elementary School; the only elementary school serving a large rural area in Southeastern Michigan. The families in this community had a wide range of incomes and educational levels. District level data indicate that 14.5% of the students qualified for free, or reduced cost, lunch. The racial profile of the district was quite homogeneous with approximately 90% of the school population of European descent. The classroom teacher, Mrs. Fé A. MacLean, was a veteran teacher of 32 years and taught first-grade at Fieldview for over twenty years. However, during the 1998-1999 school year, when data for this study were collected, Mrs. MacLean was teaching second grade. Mrs. MacLean’s teaching exemplified important tenets of GISML Instruction; including: conceptualizing the classroom as a learning community in which children are encouraged to wonder about real world phenomena and are supported in sharing their thinking about these phenomena guided by the teacher. During the year of this study, there were 21 second graders, all of whom were of European American descent, and ten of whom were girls.

1 1 All names in this paper, with the exception of Mrs. MacLean’s, are pseudonyms. Mrs. MacLean has consented to the use of her real name.
METHODS

Data Sources

Videotapes

All whole class instruction and most small group and individual (i.e., writing) activity were videotaped. All totaled, there were approximately 11 hours of videotape, which spanned the instruction over the course of 10 school days. A time analysis revealed that the majority of time (49%, or about 5 hours) was spent conducting first-hand investigations. Whole-class work with the Big Book texts comprised 35% (or almost 4 hours) of the instructional time, while the remaining time was spent engaged in writing.

In general, the camera remained on a tripod to the side of the “Big Space” area of the classroom where the class convened as a group. During whole group instruction, the research assistant operating the camera focused the camera on each speaker. During notebook writing times and other times when children were working in pairs or in small groups, the camera followed Mrs. MacLean. Sound was recorded via two boom microphones, as well as a remote microphone that Mrs. MacLean wore.

Class-generated Artifacts

The class created several types of texts as a part of the instruction. Among these was a list of “Claims About Motion” to which the class added as they conducted first- and second-hand investigations. In addition to this list, there were: (a) data tables and other
data records, (b) records of children’s predictions for various situations, and (c) publicly
displayed records of children’s ideas about several aspects of the investigations: possible
sources of experimental error for Lesley’s experiments in Big Book 1, and possible
variables to change for Lesley’s experiment in Big Book 2.

Pre- and Post- Assessments

The day before and the day after the unit of study on motion, the students completed
paper and pencil assessments about the motion of balls down inclined planes. All nine
questions on this measure were illustrated with diagrams. To minimize writing demands,
children were usually asked to circle their answer from among a group of choices. At
most, children were asked to write a number within a data table. Most of the questions
were designed to tap children’s understandings of scientific relationships such as whether
mass or ramp height would affect speed. One question asked children to evaluate several
possible experimental set ups to judge which would be “fair tests.” The assessment was
administered by Mrs. MacLean who read each question aloud from transparencies of the
test using an overhead projector.

Children’s Writing

During the 10 days of instruction for this unit of study, the children responded to five
writing prompts. These were written in response to prompts posed by Mrs. MacLean.

\[ \text{I was this research assistant for 6 of the 10 days. On the other days, I thank Karen Hopkins for her excellent videography and video field notes.} \]
During these writing times the children typically worked individually or in pairs.\(^3\) Generally, each child wrote several sentences and drew an accompanying diagram on unlined white paper.

**“Experiential” Data**

In addition to the data sources listed above, I also had access to what Strauss (1987) would call, “experiential data.” These are data “in the researcher’s head” that derive from personal and professional experiences as well as knowledge of the research literatures pertinent to any given research topic. Of particular note for this study are the many hours I have spent talking with Mrs. MacLean about her ideas regarding teaching and young children’s science experiences. I have also spent a considerable amount of time in Mrs. MacLean’s classroom over the course of several years and have therefore witnessed her science instruction with multiple classes and for several different topics. For this study, I have not used any of the formal analyses I have done with some of these data, but I am aware that they have contributed to some of the ways in which I have approached the data analyses and some of the conclusions I have reached.

\(^3\) Although the children often worked cooperatively, Mrs. MacLean emphasized that children were to write their own ideas, even if these conflicted with their partner’s views.
Data Preparation and Analysis

Transcripts of videotapes

Transcripts were prepared by a commercial service. Additions and corrections to these transcripts were made during multiple viewings of the videotapes. In addition, remarks regarding intonation patterns and gestures were added to the transcripts.

Time-use analysis

All video-tapes were analyzed to create a detailed time-use analysis. The resulting table showed a to-the-minute account of the activities in which the class was engaged.

Content Analysis of Children’s Writing

A File Maker database was created for all of the children’s written work. The children’s invented spellings and punctuation were maintained, but - for ease of reading and analysis - conventional spellings were inserted in parentheses. This database was searchable by child and date. Thus, one could look at changes within individual children’s entries, as well as across all students’ entries, for a specific date.

These content of these writings were analyzed in various ways depending on the nature of the prompt. For example, I looked across related prompts (e.g. for Days 1 & 2) to determine if children’s ideas and/or ways of justifying and illustrating their ideas had changed. For all writings, analyses focused on the range of ideas expressed in addition to the extent to which children justified their ideas with specific evidence.
Instructional Content Analyses

The analyses most important to this dissertation consisted of a series of content analyses of the videotapes and transcripts. These analyses involved a multiple stage process. The first stage involved creating a “master transcript” for each day of the instruction. In these documents I numbered all the lines of corrected transcript. The next stage involved “chunking” the master transcripts into sections, each of which I interpreted to be about a particular idea or set of related ideas. Keeping the temporal organization of the transcripts, I transferred each “idea chunk,” now labeled with master transcript line numbers, into a large analysis chart that I created using Microsoft Word software. In the third stage of the content analyses I wrote detailed comments and observations for each idea unit in turn. I entered these into the analysis chart in a column adjacent to the transcript excerpt which I labeled “key issues/ideas.” This activity served the purpose of allowing me to begin to “cook” the data as I tried to understand what had happened during the instruction [Bogdan, 1992 #195]. In essence, the comments in this column were like field notes with “open coding” (Strauss, 1987) in that I wrote both low-inference observations to augment the transcript as well as impressions, critiques, and questions I had about the data.

The next phase of the content analyses involved several activities, which did not always occur in a consistent sequence. Rather, I tacked back and forth among the various components of the analyses (Strauss, 1987; Huberman & Miles, 1994). Usually, I first analyzed each idea chunk to identify evidence of science “concepts” expressed and of scientific “reasoning” being engaged in. These I noted in additional columns. Then, going back to the raw transcript as well as my initial notes about “key issues/ideas” I teased out the many and varied “moves” or “actions” that Mrs. MacLean employed.
These were noted in yet another column. Finally I also wrote a “summary” statement for each idea chunk in an attempt to create a more concise synthesis.

In deciding what to include in these columns (save the actual transcript), I used my knowledge of Mrs. MacLean’s class, my best efforts to understand what the children and Mrs. MacLean meant in situ, as well as ideas and categories of actions I know to be important in the various literatures that speak to issues examined in this study. Thus, my process was not purely inductive nor deductive, but a combination of both (Stake, 1994). Similarly, my decisions about how to describe various aspects of the activity result from an attempt to combine “emic” (ways of understanding close to those expressed by the participants in the field), and “etic” (ways of categorizing that derive from sources the outside the field situation) descriptions [Bogdan, 1992 #195]. Figure 3 is a randomly selected excerpt from an analysis chart for Day 8 that includes only 2 relatively brief ideas units. This represents only a very small fraction of the thousands of lines of transcript that were analyzed.
For the ideas that were expressed regarding the physics of motion (noted in the “concepts” column) I engaged in an additional step. I created a “idea time line” which shows the range of ideas “on the floor” during any given time. I organized short-hand descriptions of the ideas that were expressed into categories that were based on some of the basic science concepts pertinent to the study of motion (i.e., ideas related to the variable of mass, speed, ramp height, momentum, or some combinations of these). This document is reproduced in Appendix XX.

Analysis of Pre – and Post- Assessments

I entered the children’s responses on the 9-question pre- and post-assessment into and Excel spreadsheet. I scored these data and ran multiple analyses to examine them for looking at class and individual-child level results. Given the small sample size, and non-normal distributions for the children’s total scores (pre- and post-), I used a non-
parametric statistic (the Wilcoxon signed-ranks test) to test for pre- to post-score change. I also looked closely at patterns in children’s answer choices among related questions. Selective, yet detailed analyses of the pre- and post-assessments are reported in Appendix XX.

More Methodological Musings

The Utility of Case Studies

As mentioned earlier, this dissertation is a case study. Interpretivist methodologies with their focus on process and rich description is well suited to the sociocultural perspective I bring to this work. In this study I pose a general question about the experiences of one class in one classroom, thus this is a single case study. What, one may well ask, can be learned from one case? Stake suggests that “the utility of case research to practitioners and policy makers is in its extension of experience” (1994, p. 245). By this he is referring to the potential of case studies to convey the sense of “having been there” to readers in order to highlight various aspects of a (perhaps) familiar situation for consideration. Donmoyer expands on this idea by suggesting that there are three “advantages” to the “vicarious experience” that may be afforded by case studies. First, case studies can provide “access” to places we might not otherwise have the opportunity to experience. Second, case studies “allow us to look at the world through the researcher’s eyes and, in the process, to see things we otherwise might not have seen” (p. 194), and finally Donmoyer suggests that case studies may “decrease the defensiveness” of the reader. When one is less directly involved in an experience, it affords the opportunity to make the case an object for repeated and reflective
consideration. Case studies can have both “intrinsic” as well as “instrumental” interest, in that they can be about a particular and interesting instance of something as well as contribute toward more general theory building regarding a large class of activity or experience (Stake, Strauss, Patton). I certainly hope that readers of this study will have the sense that they come to “know” Mrs. MacLean, her students, and the intellectual terrain they traversed. In addition, I hope that the study will be both intrinsically interesting to readers as well as “instrumental” in opening up the discussion of what is possible for the teaching of science in primary grades.

Minimizing Threats to Validity

I have sought to strengthen the validity of this research in a variety of ways. First, I have created a data analysis process that would allow for another person to examine my train of thinking about those data – an “audit trail” as Janesick (1994) would call it. Second, I have used multiple sources of data and used various methods to record and organize these data. This has allowed me to examine the data multiple times, which in turn has allowed me to compare and refine my initial impressions and analyses over time. This increases what Maxwell would call both the “descriptive” and “interpretive” validity of the study (1992). In addition, throughout this work I have tried to provide the reader with enough examples and raw data that one may evaluate the soundness of my interpretations. Finally, I have a great deal of “experiential data” to draw upon. This means that, although it decreases the possibility that another person who is unfamiliar with Mrs. MacLean’s classroom or with my “audit trail,” would reach exactly the same set of conclusions as I have, it increases the possibility that, as Wolcott (1992) might say, I have not “gotten it all wrong.”
Exploring My Biases

In the great tradition of qualitative research, much importance is put upon making explicit one’s biases and reactions (Behar, 1996; Wolcott, 2001). I am particularly aware of my own biases about young children’s capacities for abstract thought. I believe that young children are more capable of deep engagement with challenging abstract ideas than is often been acknowledged in the early childhood education literature (Bredekamp, 1987; Elkind, 2000). Knowing that my tendency would be to seek out positive examples of the children’s engagement with ideas during the motion program of study, I designed a system for data analysis that forced me to check for negative examples and opportunities missed.

Another of my biases is that I think Mrs. MacLean is simply an extraordinary teacher. My regard for her thoughtfulness and competence only increases with time. Indeed, it is because of my respect for the kind of learning community Mrs. MacLean fosters in her room, that I chose to examine data from her class. I make no claims about the typicality of her teaching or approach to teaching, although I have tried to characterize the context she works to create. I’m sure that not all the students in her class experienced her instruction in the same way. I have tried to capture some of that variability throughout this work.

Concluding Thoughts About the Methodology for this Study

As Robert Stake has written, “Many a researcher would like to tell the whole story but of course cannot: the whole story exceeds anyone’s knowing, anyone’s telling” (1994, p. 240). I am certainly guilty of wanting to tell the whole story of Mrs. MacLean and her second graders. I have been compelled to make many choices about what to
focus on and how to present my interpretations of the rich and complex world of their investigations about motion. Throughout, I have tried to keep the admonitions Philip Jackson (1990) has proposed as a summary of Wolcott’s approach to validity. Namely, “to be as credible, balanced, fair, complete, sensitive, rigorously subjective, coherent, internally consistent, appropriate, plausible, and helpful as possible” (p. 154).